Towards Standardized Assessment of Paraspinal Muscle Using MRI

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Background

- There is increasing interest in paraspinal muscle (PSM) morphology, composition and asymmetry and their relation to painful spinal conditions, including lower back pain (LBP).
- Most attention has been focused on the lumbar multifidus muscle (MM) and erector spinae muscle (ESM).
- A systematic review by Ranger et al (2017) reported that MM cross-sectional area (CSA) is both negatively associated with, as well as predictive of LBP for a maximum of twelve months. There was conflicting and limited evidence, however, to support associations of other paraspinal muscle phenotypes and LBP.[1]
- Variations in PSM measurement methods are suspected to contribute to the observed inconsistencies across studies' findings, yet there is little information on the effects of such methodological variations on muscle measurements.
- While several imaging modalities are used, T2-weighted magnetic resonance images (MRI) are preferred for PSM measurement.

Objectives

We sought to investigate the effects of two of the most common variations in PSM measurement on muscle CSA and fatty infiltration

Objective 1

Location of PSM measurements, specifically at the mid-disc vs. inferior endplate level.

See Figure 1.

Objective 2

Muscle segmentation protocols for MM and ESM that either include the fat regions lateral to iliocostalis and under the fascial plane or epimysium (protocol 1) or excluding these fat regions (protocol 2)[2].

See Figure 2.

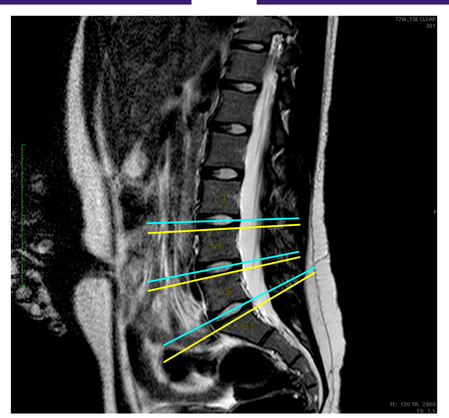

Figure 1: T2-weighted MRI sagittal view of vertebrae. Axial slices were taken at the mid-disc level of L3/4, L4/5, L5/S1 (blue) and at the corresponding inferior endplate level (yellow)

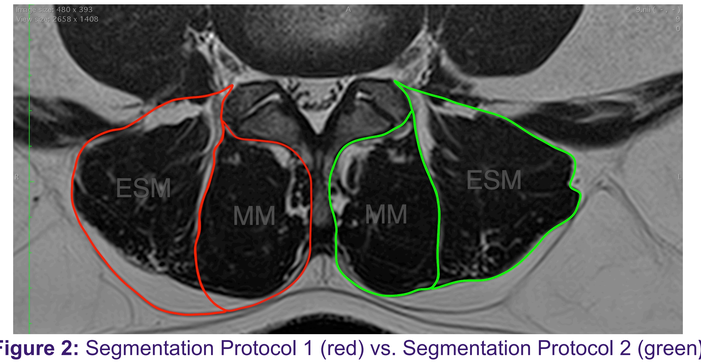

Figure 2: Segmentation Protocol 1 (red) vs. Segmentation Protocol 2 (green)

Methods

- Lumbar MRIs came from participants of Genodisc, a European research consortium project on commonly diagnosed lumbar pathologies in patients attending spine surgeon clinics.
- A stratified, random sample was selected to include 20 women and 20 men in each of the three following age groups: 31-40, 41-50, 51-60; totalling 120 subjects.
- Axial T2-weighted MRI were selected at L3/L4, L4/L5, L5/S1 at two locations – mid-disc and inferior endplate. These MM and ESM measurement locations are most commonly studied in the literature (Figure 1).
- Six assessors were responsible for MM and ESM bilateral muscle segmentation at L3/4, L4/5, L5/S1 at mid-disc and corresponding inferior endplate levels using protocol 1. One assessor was responsible for MM and ESM bilateral muscle segmentation at L3/4, L4/5, L5/S1 at mid-disc level using protocol 1 and 2 (Figure 2).
- ITK-SNAP segmentation software was used to perform manual segmentation.
- Descriptive statistics consisting of means and standard deviation were used to describe CSA (mm^2) and fatty infiltration (%) of MM and ESM for the right and left sides for both sexes at L3/4, L4/5, and L5/S1 at mid-disc and the corresponding inferior vertebral endplate. Paired t-tests were used to determine if the values obtained at the two sites were statistically significantly different. Pearson correlation coefficients (ρ) were then used to see how measurements obtained at mid-disc correlated with the analogous measurements at the inferior vertebral endplate.

Results

Objective 1

- Mid-disc CSA of MM and ESM was consistently greater than or equal to corresponding inferior endplate CSA across the L4/5 and L5/S1 levels for both males and females (Figure 3).
- The highest correlations between mid-disc and inferior endplate CSA were observed at the L5/S1 level (ρ=0.82-0.87) and lowest at L3/4 (ρ=0.43-0.87).

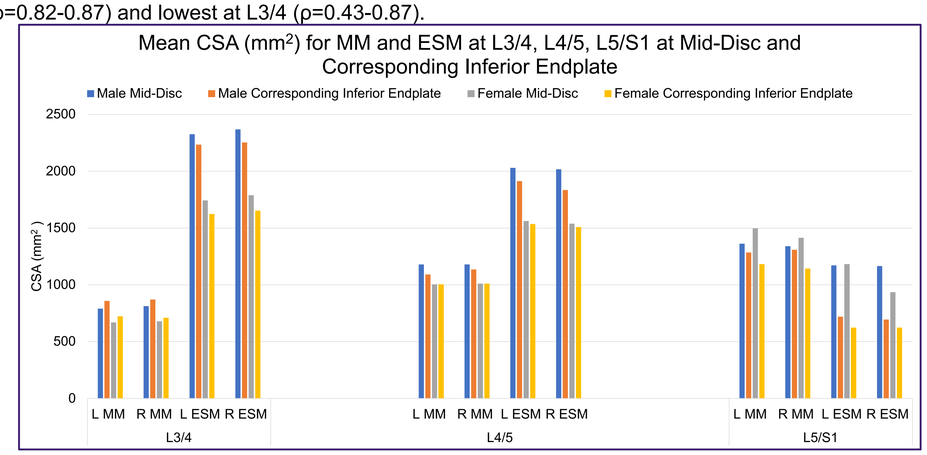

Figure 3: CSA of mid-disc MM and ESM was greater than or equal to CSA at corresponding inferior endplate MM and ESM at L4/5 and L5/S1 levels

Objective 2

- The two different segmentation protocols also resulted in significantly different ESM measurements (MM results pending).
- ESM CSA was greater for segmentation protocol 1 than segmentation protocol 2 at L3/4, L4/5, and L5/S1 (Figure 4).
- ESM fat percentage was also greater for segmentation protocol 1 than segmentation protocol 2 at L3/4, L4/5, and L5/S1 (Figure 5).

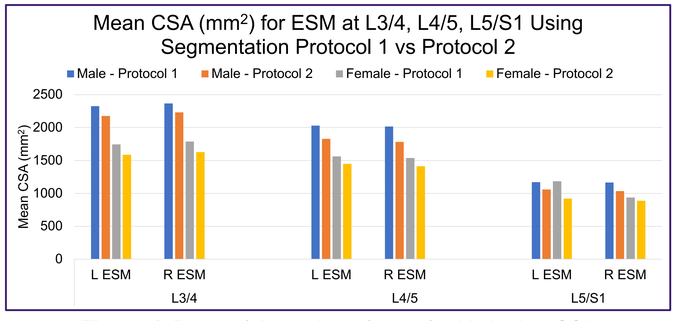

Figure 4: Protocol 1 consistently resulted in higher CSA measurements for left and right ESM than Protocol 2 in both males and females at the L3/4, L4/5, L5/S1 levels.

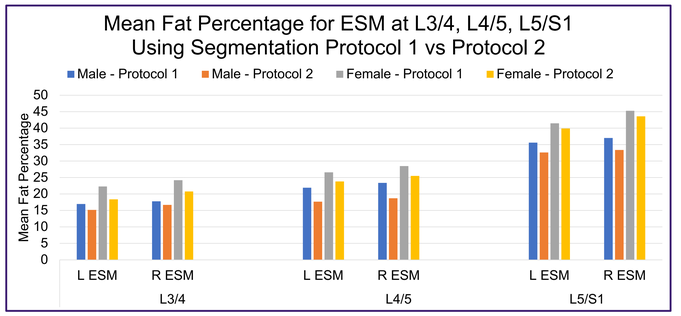

Figure 5: Protocol 1 consistently resulted in higher fat percentage measurements for left and right ESM than Protocol 2 in both males and females at the L3/4, L4/5, L5/S1 levels.

Conclusions

- Common methodological variations in PSM measurement significantly affect CSA and fat% measurements.
- The lack of standardization of PSM measurements complicates comparisons of findings between studies and prevents pooling of data for meta-analyses.
- Standardization in PSM measurements is needed to move the field forward.

References

1. Ranger TA, Cicuttini FM, Jensen TS, Peiris WL, Hussain SM, Fairley J, Urquhart DM (2017) Are the size and composition of the paraspinal muscles associated with low back pain? A systematic review. The spine journal : official journal of the North American Spine Society 17(11):1729–1748.
2. Berry, D. B., Padwal, J., Johnson, S., Parra, C. L., Ward, S. R., & Shahidi, B. (2018). Methodological considerations in region of interest definitions for paraspinal muscles in axial MRIs of the lumbar spine. BMC Musculoskeletal Disorders, 19(1), 135–135. https://doi.org/10.1186/s12891-018-2059-x

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